Update on IMERG, the U.S. Multi-Satellite Algorithm

On the Verge of Version 06

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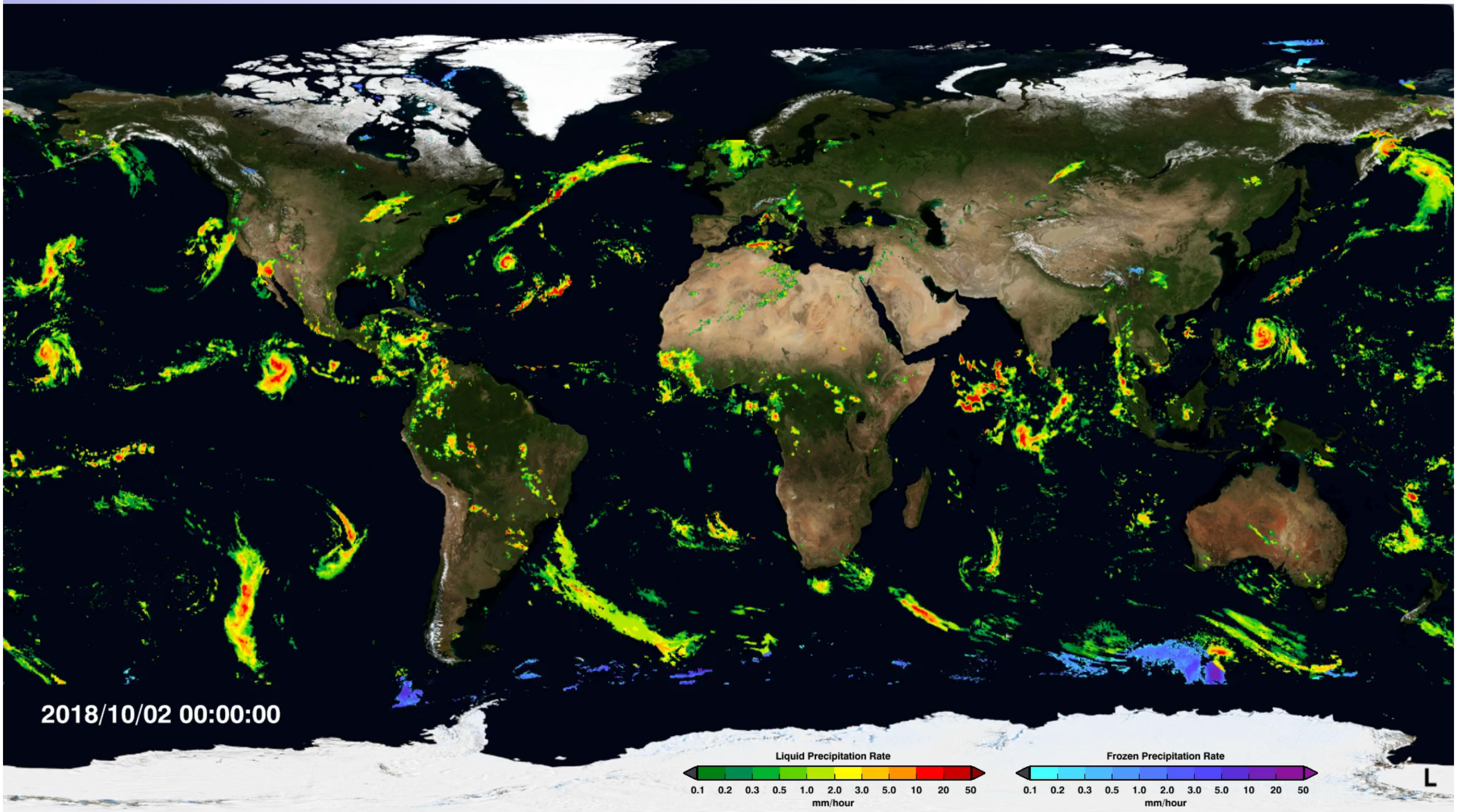
V05 IMERG – Near-Real-Time Run for 2–9 October 2018



http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4285
30 min. maps on a 0.1° x 0.1° grid, morphing 60° N-S

1. VERSION 05 IMERG – Beck et al. CONUS Validation (1/2)

Daily evaluation against Stage IV

- 2008-2017 for TMPA, 2014-2017 for IMERG
- evaluated using the Kling-Gupta Efficiency

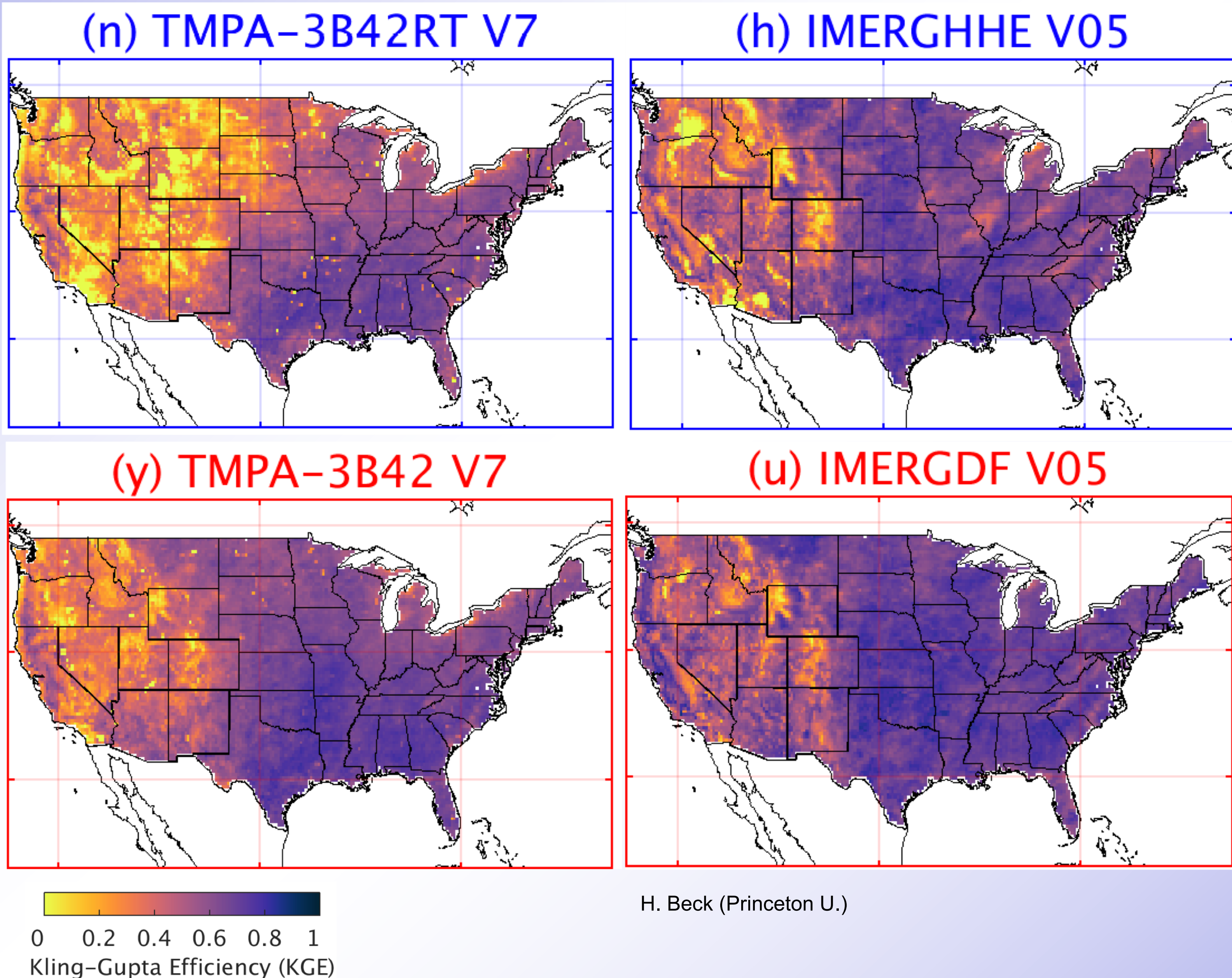
$$KGE = 1 - \sqrt{(r-1)^2 + (\beta - 1)^2 + (\gamma - 1)^2}$$

where r = Pearson correlation, $\beta = \frac{\mu_s}{\mu_o}$, and $\gamma = \frac{\sigma_s/\mu_s}{\sigma_o/\mu_o}$

- IMERG improves over TMPA for the same latency
- in both, monthly gauge is helpful (at least in bias)
- TMPA falters north of ~40° N, while IMERG does better
  - TMPA calibration stops at 40° N, while IMERG goes to 65° N
  - the challenge in V06 is to improve the TRMM era
- the mountains are an issue in both (and Stage IV less sure)
- statistics are shown for 26 datasets – satellite with and without gauge, and reanalyses:

  Beck, H., M. Pan, T. Roy, G. Weedon, F. Pappenberger, A. van Dijk, G.J. Huffman, R.F. Adler, E. Wood, 2018: Daily Evaluation of 26 Precipitation Datasets Using Stage-IV Gauge-Radar Data for the CONUS. *Hydrol. and Earth Sys. Sci.*, submitted (and posted at *HESSD*).

1. VERSION 05 IMERG – Beck et al. CONUS Validation (2/2)



H. Beck (Princeton U.)

2. VERSION 06 IMERG – Upgrades

Morphing vector source switched to MERRA-2/GEOS-5

Morphed precip for all non-icy/snowy surfaces, including in polar regions

Full intercalibration to 2BCMB – V05 took shortcuts

Quality Index modified for half-hourly

Modifications for TRMM era – primarily estimating the calibration for the band 35° - 65° in both hemispheres

Revisions to internals raises the maximum precip rate from 50 to 200 mm/hr and no longer discrete

2. VERSION 06 IMERG – Morphing (1/3)

Main steps in morphing:

- derive motion vectors from successive fields of an atmospheric variable
- propagate the precipitation pixels between successive PMW precipitation fields using the motion vectors
  - recall that Early is forward-only; Late and Final are backward-forward
  - in all three, a Kalman filter combines the propagations with IR precip

IMERG uses the CMORPH scheme

- up through V05 this included using IR to compute the motion field
- archival issues with the IR led us to develop alternatives sooner than expected

Tested fields from Goddard Modelling and Assimilation Office (GMAO) numerical products

- MERRA-2 reanalysis for Final
- GEOS-5 forecast for Early and Late
- hourly 0.5° x 0.625° (MERRA) and 0.25° x 0.3125° (GEOS)
- total column water vapor (TQV) was the most satisfactory

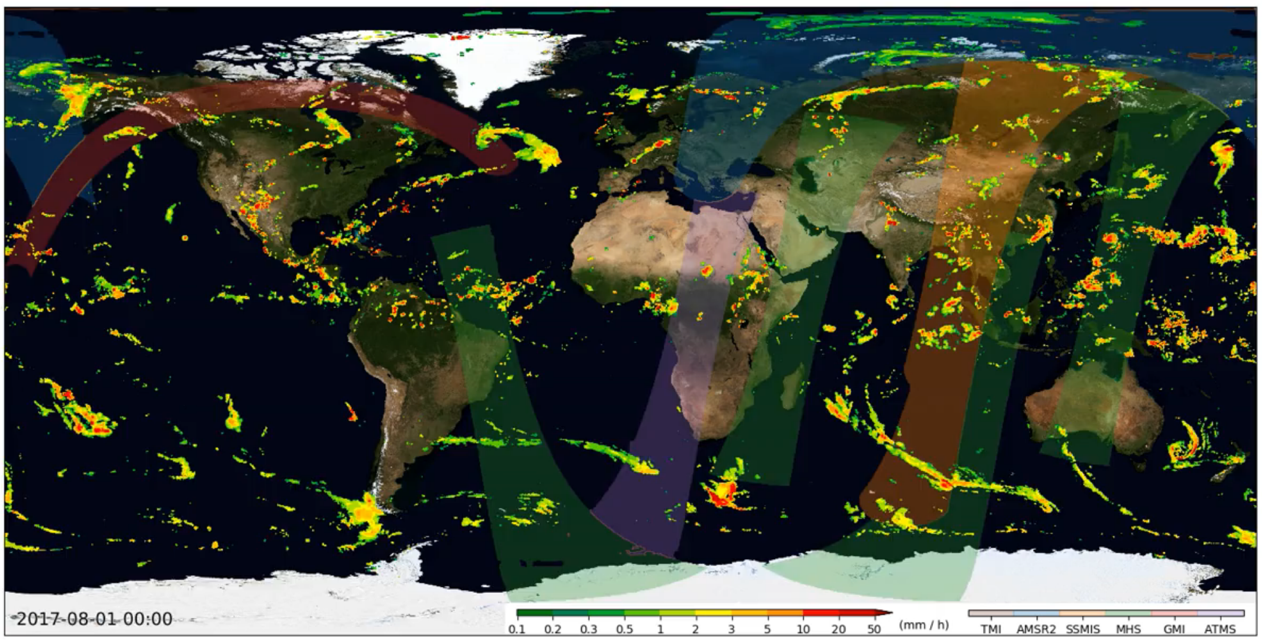
2. VERSION 06 IMERG – Morphing (2/3)

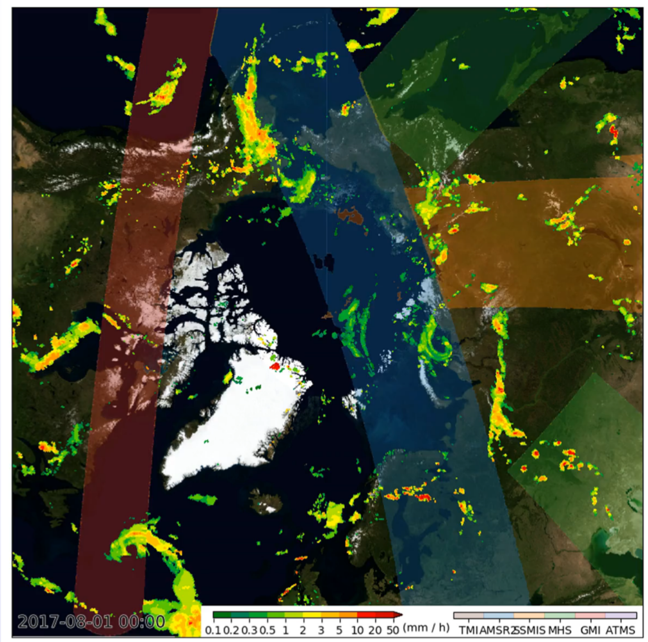
TQV is fully global, so morphing vectors are as well

- but we still don't consider GPROF over snowy/icy surfaces to be reliable
  - IR-based precip still limited to 60° N-S, so actual fields have holes for snowy/icy surfaces in polar regions
- we need to move away from CED as the native grid to correctly handle the poles

Example animations, with half-hour satellite swaths, before masking for ice/snow:

1-5 August 2017



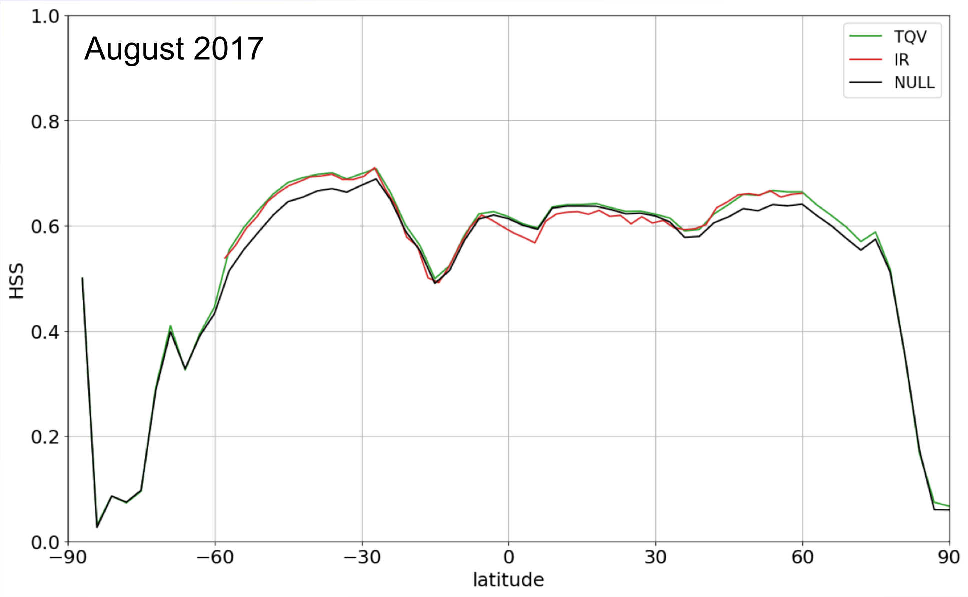


J. Tan (USRA, GSFC)

2. VERSION 06 IMERG – Morphing (3/3)

Example evaluation using Heidke Skill Score

- approach: propagate PMW precipitation field from *t* to (*t* + 1) and validate the resulting field against the (*t* + 1) MW precipitation field where available
- compare the TQV-based morphing scheme against two benchmarks: IR and "NULL" (no motion)



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TQV tends to follow the higher of the other two

There are residual issues that require continued attention

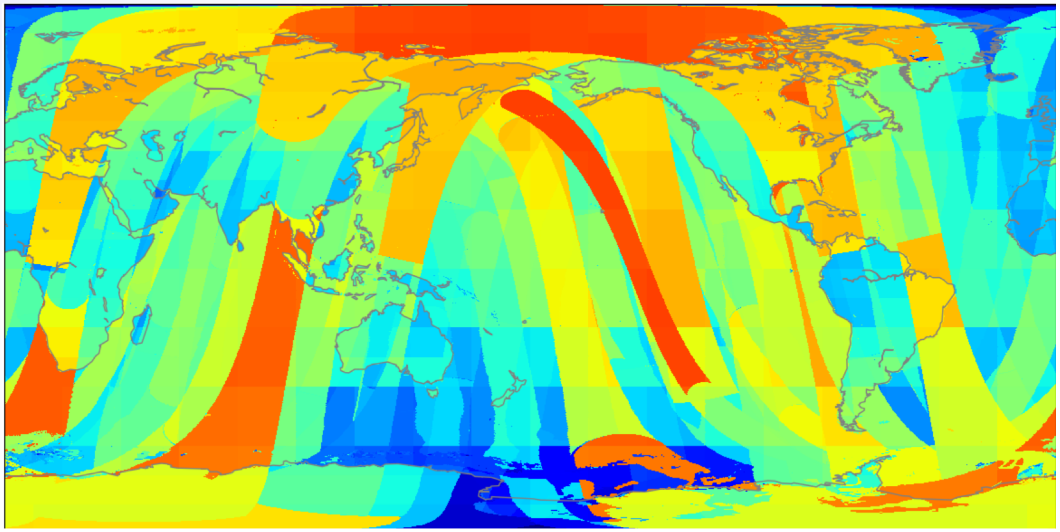
2. VERSION 06 IMERG – Quality Index (QI)

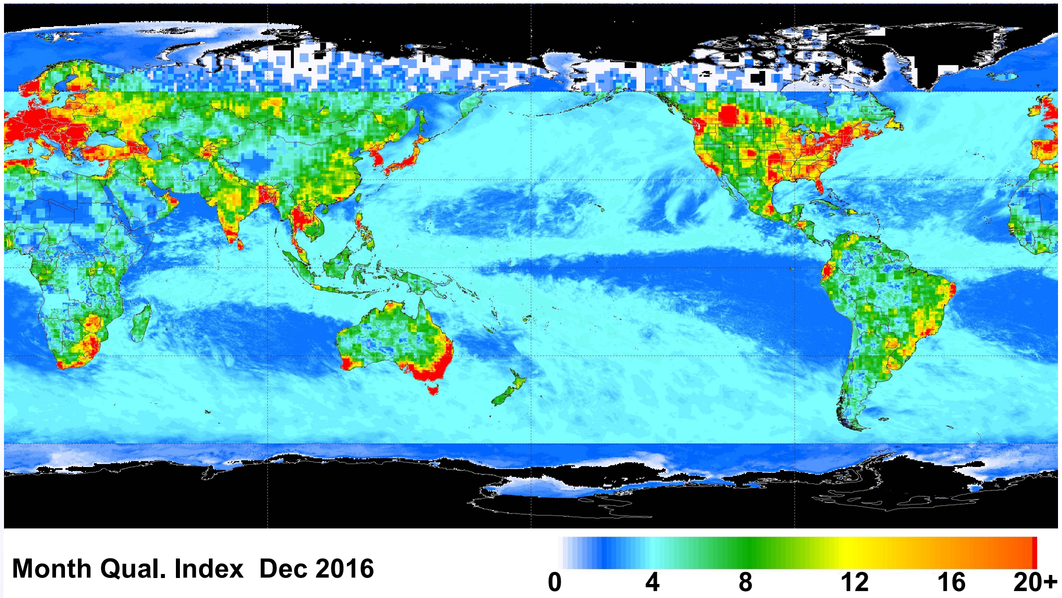
Half-hourly QI (revised)

- approx. Kalman Filter correlation
  - time(s) to nearest PMWs
  - IR at time (when used)
  - estimate *r* when a PMW is used
  - work at 0.1° (old was 0.25°)
- thin strips due to inter-swath gaps
- blocks due to regional variations

Monthly QI (unchanged)

- Equivalent Gauge (Huffman et al. 1997) in gauges / 2.5° x2.5°
- invert random error equation
- largely tames the non-linearity due to rain amount
- some residual issues at high values





D.Bolvin (SSAI; GSFC)

3. FUTURE – Version Transitions

Early January 2019: begin Version 06 IMERG Initial Processing and Retrospective Processing

- the GPM era will be launched first, Final Run first
  - Early and Late retrospective processing use Final intermediate files, so they come after Final
  - complete data should take about a month

    except Final is always ~3.5 months behind, so the Early and Late retrospective processing have to wait on Final Initial Processing to fill in the last 3 months of 2018
- the TRMM era will be launched after the GPM era is underway
- the Final-then-Early/Late pacing is true here as well
- complete data will take about 4 months using serial processing
- 4 km merged global IR data files continue to be delayed for January 1998-January 2000
  - the run will build up the requisite 3 months of calibration data starting from February 2000
  - the first month of data will be for June 2000
  - the initial 29 months of data will be incorporated when feasible

~2 years later: Version 07

3. FUTURE – Version 07 (and Beyond) Concepts

Multi-satellite issues

- improve error estimation
- develop additional data sets based on observation-model combinations
- work toward a cloud development component in the morphing system
- use sub-monthly gauge data

General precipitation algorithmic issues

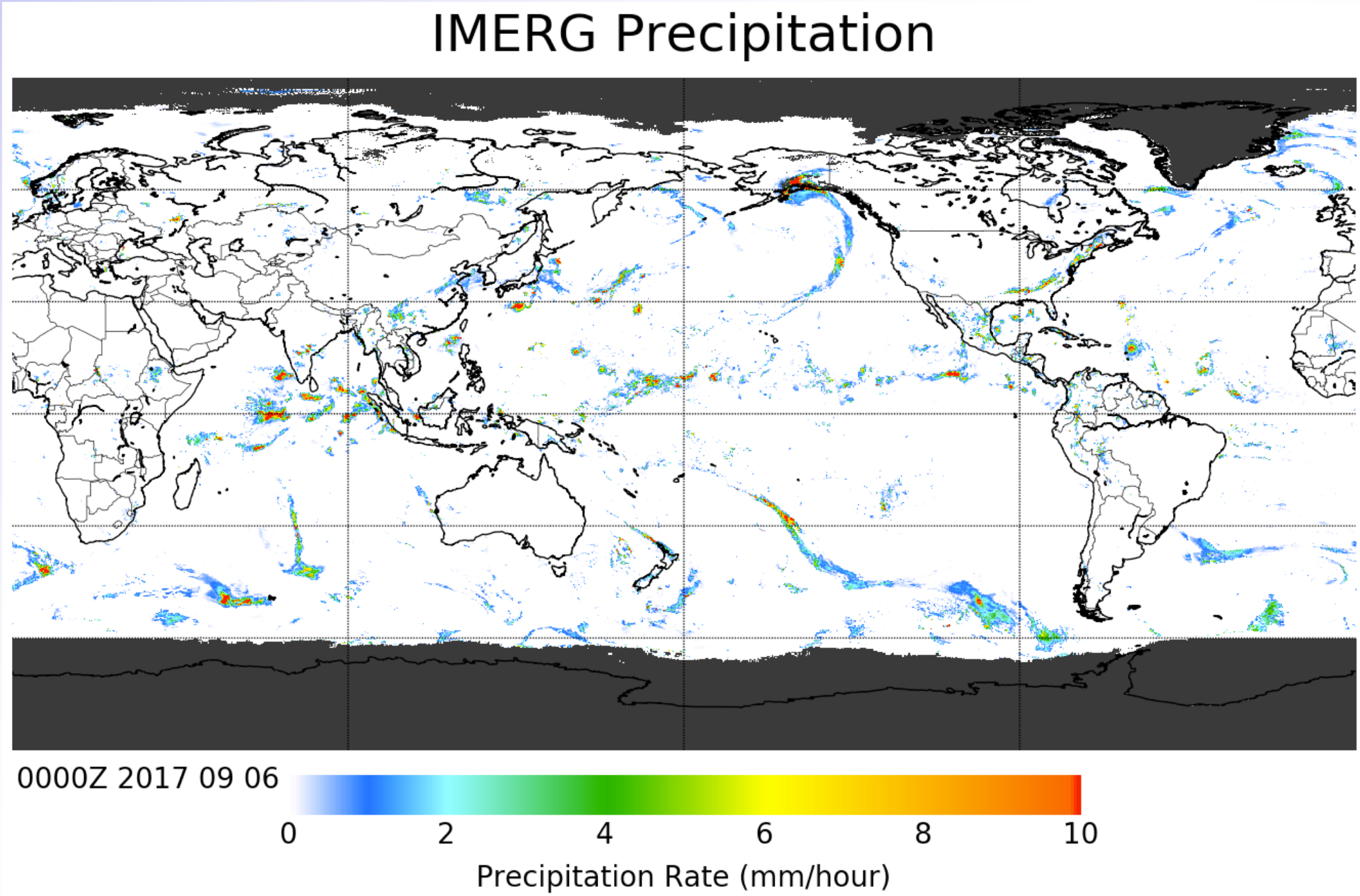
- introduce alternative/additional satellites at high latitudes (TOVS, AIRS, etc.)
- evaluate ancillary data sources and algorithm for Prob. of Liq. Precip. Phase
- track quality of PMW retrievals over snow/ice
- track quality of PMW retrievals in complex terrain
- work toward improved wind-loss correction to gauge data

IMERG testbed

- provide a way for researchers to experiment with running alternative precipitation data through IMERG
- beta test is configured as compiled modules and pre-computed intermediate files (morphing vectors, for example) running on GSFC machine
- development depends on resources and interest

4. IMERG V06 Alpha Test

6-11 September 2017



GET DATA
GLOBAL PRECIPITATION MEASUREMENT
New Users Start Here

0. INTRODUCTION

Input **precip** estimates

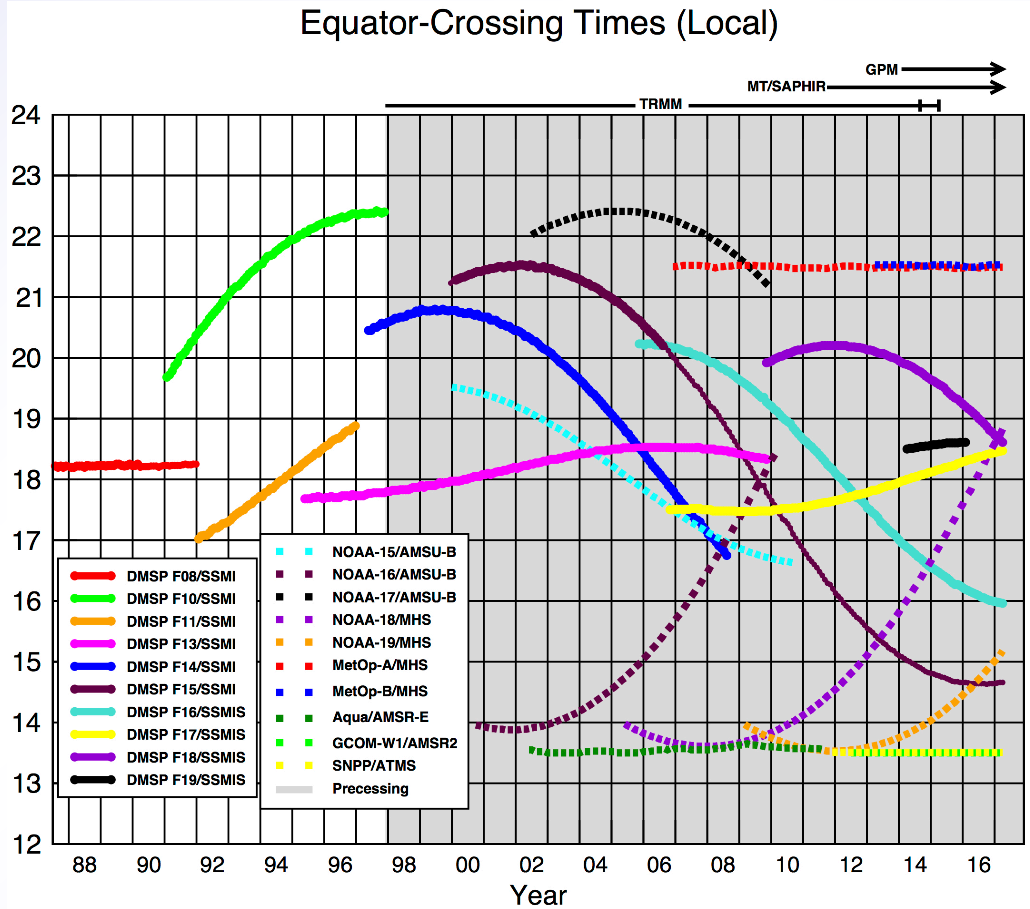
- GPROF (LEO passive microwave [PMW])
- PERSIANN-CCS (GEO infrared)

Goal: seek the longest, most detailed record of "global" precip

IMERG is a unified U.S. algorithm that takes advantage of

- Kalman Filter CMORPH (lagrangian time interpolation) – NOAA
- PERSIANN-CCS (IR) – U.C. Irvine
- TMPA (inter-satellite calibration, gauge combination) – NASA
- PPS (input data assembly, processing environment) – NASA

GSMaP is Japan's merged product



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day.
Image by Eric Nelkin (SSAI), 25 April 2017, NASA/Goddard Space Flight Center, Greenbelt, MD.

0. IMERG DESIGN – Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- "Early" – 4 hr (flash flooding)
- "Late" – 14 hr (crop forecasting)
- "Final" – 3 months (research)

Time intervals are half-hourly and monthly (Final only)

0.1° global CED grid

- merged PMW precip 90° N-S
- morphed precip 60° N-S for now
- probability of liquid precip 90° N-S

User-oriented services by archive sites

- interactive analysis (Giovanni)
- alternate formats (TIFF files, …)
- value-added products

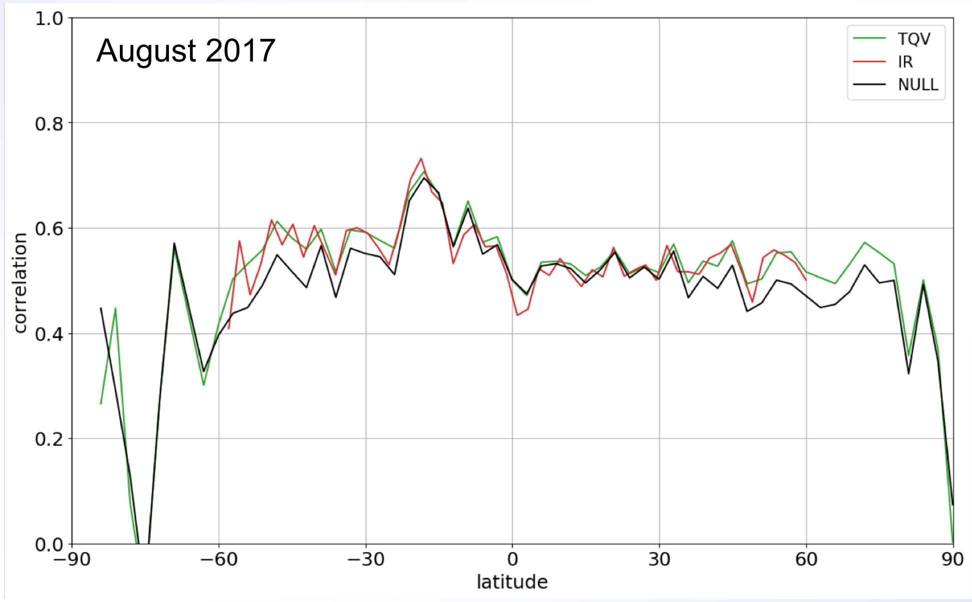
	Half-hourly data file (Early, Late, Final)
1	*[multi-sat.] precipitationCal*
2	[multi-sat.] precipitationUncal
3	*[multi-sat. precip] randomError*
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	*[phase] probabilityLiquidPrecipitation*
10	*precipitationQualityIndex*
	Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*
5	*precipitationQualityIndex*

2. VERSION 06 IMERG – Morphing

Example evaluation using Zonal Mean Correlation

- approach: propagate PMW precipitation field from *t* to (*t* + 1) and validate the resulting field against the (*t* + 1) MW precipitation field where available
- compare the TQV-based morphing scheme against two benchmarks: IR and "NULL" (no motion)

As with HSS, TQV tends to follow the higher of the other two, but more variably



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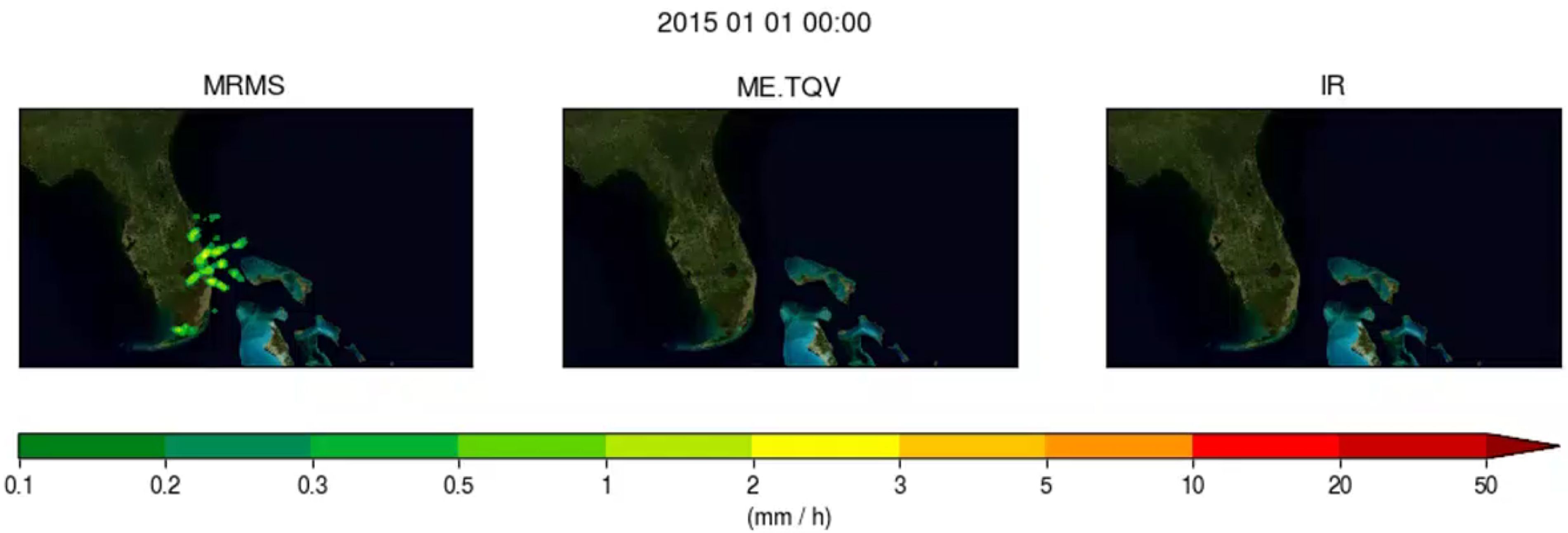
2. VERSION 06 IMERG – Case Study for Shear

Example of sheared flow

- TQV catches the (apparent) low-altitude motion better than IR

Jumpiness due to both vector errors and successive satellite swaths



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